

# Physics and Metaphysics

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**Аннотация.** Experiment plays a decisive role in physics. It is the single source of our understanding of nature. But, during the last century the main accent in theoretical physics has moved toward metaphysics. Some mathematicians/theoreticians try to develop new approaches, ignoring experiments. Three examples of such treatment are discussed here: the Gutzwiller approach, the classical description of the tunneling phenomenon and the role of irregular motion in classical mechanics. The foundations of special relativity are also discussed.

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Красота - не прихоть полубога  
А хищный глазомер простого столяра  
(In English: Beauty is no demigod's whim,  
It's the plain carpenter's fierce rule-of-eye.)

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O.Mandelstam

## 1. Introduction

This paper can be considered as a continuation of previous papers [1, 2] dedicated to the interpretation of quantum physics. From the very beginning the interpretation of quantum theory has gone in an erroneous direction. Already the name 'quantum *mechanics*' implies that it is an expansion of classical mechanics concerning the behavior of particles on the atomic scale. Actually, quantum theory deals with a new object - an information field  $\Psi(\mathbf{r})$  (see [1, 2]), like classical mechanics - with a material point  $\mathbf{r}_i(t)$ , and like classical electrodynamics - with an electromagnetic field  $\{\mathbf{E}(\mathbf{r}), \mathbf{H}(\mathbf{r})\}$ . The radius-vector  $\mathbf{r}$  in  $\Psi(\mathbf{r})$  has the same meaning as in the electromagnetic field  $\{\mathbf{E}(\mathbf{r}), \mathbf{H}(\mathbf{r})\}$ . At the moment of measurement, which plays the role of 'interaction' between particle  $\mathbf{r}_i(t)$  and the information field  $\Psi(\mathbf{r})$ , the result of measurement is obtained by the replacement  $\mathbf{r} = \mathbf{r}_i(t)$  in the information field as in the case of the interaction of a charged particle with the electromagnetic field. Thus the 'information field' is a substance additional to 'material points' and 'electro-magnetic waves' but without mass and energy. This statement is in contradiction with wave-particle duality.

In the present interpretation we have material points characterized by  $\mathbf{r}_i(t)$ , and the 'information field'  $\Psi(\mathbf{r})$  which is subject to the wave-type Schrödinger equation. For photons the role of the Schrödinger equation is played by the Maxwell equations which predict the propagation of the flux of photons. Here the electromagnetic field  $\{\mathbf{E}(\mathbf{r}), \mathbf{H}(\mathbf{r})\}$  acts as an 'information field'. Thus, there is no duality because of two different substances - material points and information field. The existence of the information field follows from the Einstein-Podolsky-Rosen *experimentum crucis* which shows that at the moment of measurement the propagation of quantum information is at least  $10^4$  times faster than the propagation of light [3], i.e. we have a new, non-material (without mass-type characteristics) object - *the information field*.

All experimental devices are designed on classical principles and a single measurement gives the fixed value of the measured classical quantity. After multiple repetition of measurement we obtain the distribution of the classical quantity according to an information field  $\Psi(\mathbf{r})$ . Thus, the probabilities arise at a measurement stage in the transfer of the data from the quantum to the classical level. Though intuitively everyone understands what measurement is, it cannot be formalized, i.e. be described in a mathematical form. Sometimes measurement is considered as a 'collapse' of the wave function. However, such word-play explains nothing.

Up to now ignorant interpretations of quantum physics exist, and they are intensively discussed in the literature. For instance, the so-called 'hidden variable theory' (see, e.g., Wikipedia) which is in total contradiction to the electron diffraction phenomenon in the experiment involving propagation of a beam of non-interacting (or one by one) electrons through a crystalline grid (or two slits). In this experiment one electron leaves one dot on the screen, and the distribution of dots has a diffraction profile predicted by quantum theory. Can this distribution be explained in terms of 'hidden variables theory'?

Metaphysics was formulated by Aristotle (384 BC-322 BC). Its basic statement is that true knowledge can be obtained only through logic. Metaphysics was the only way for investigation of the Universe until Galileo Galilei (1564-1642), who formulated the *scientific* approach to the study of inorganic nature - *Physics*. First of all, Galileo Galilei discovered the fundamental role of experiments in inorganic nature - physical events are reproduced at any place and any moment under the same external conditions i.e., they obey the laws of nature which take the form of mathematical equations introduced by Isaac Newton. Thus, experiment is the single source of the understanding of nature. But, during the last century the main accent in theoretical physics moved toward metaphysics. Some mathematicians/theoreticians try to develop new approaches based only on logic, ignoring the experimental background of physics. Of course, physical theories use mathematics. But mathematics is a logical scheme related more to our mentality than to nature. In principle, mathematics does not produce new information; its aim is the transformation, according to its axioms, of the initial expression to a form more transparent for our consciousness, e.g., by solution of a differential equation. Thus, mathematics plays a subordinate role in physics. Investigations based only on

the abstract mathematical background lead, sometimes, to artifacts. To illustrate this statement, three examples of such metaphysical approaches are presented below.

## 2. The Gutzwiller approach

The first example is the Gutzwiller 'theory'. In this approach, the contribution of the unstable periodic orbit to the trace of the Green function is determined by the formula [4]

$$g(E) \sim -\frac{iT(E)}{2\hbar} \sum_{n=1}^{\infty} \frac{\exp\{in[S(E)/\hbar - \lambda\pi/2]\}}{\sinh[nw(E)/2]} \quad (1)$$

where  $S(E)$ ,  $w(E)$ ,  $T(E)$  and  $\lambda$  are the action, the instability exponent, the period and the number of focal points during one period, respectively. After the expansion of the denominator, according to  $[\sinh(x)]^{-1} = 2e^{-x} \sum_{k=0}^{\infty} e^{-2kx}$ , and summation of the geometric series over  $n$  one can see that the response function (1) has poles at complex energies  $E_{ks}$  whenever

$$S(E_{ks}) = \hbar\lambda\pi/2 - i\hbar w(E_{ks}) \left(k + \frac{1}{2}\right) + 2s\pi\hbar, \quad k, s = 0, 1, 2, \dots, \quad (2)$$

which are treated as resonances of the concerned system. The Gutzwiller approach was widely applied to different few-body systems - the scattering of electrons on the Coulomb potential in the presence of external magnetic [5, 6] and electric fields [7, 8], and the scattering on the two-Coulomb-center potential [8] *etc.* However, this approach has been introduced *ad hoc*. It is based on local characteristics in the vicinity of the periodic orbits ignoring the asymptotic region which is responsible for the physical boundary condition. Thus, in this scheme it is impossible to distinguish whether the energy belongs to the discrete spectrum or the continuum. Besides, in nonseparable systems unstable periodic orbits with long periods lie everywhere dense in phase space (renormalization-group) and the response function (1) has a pathological structure like the Weierstrass function which is continuous everywhere but differentiable nowhere. The singularities predicted by expression (1) have no physical meaning in the case of the discrete spectrum as well, since the energies  $E_{ks}$  are complex.

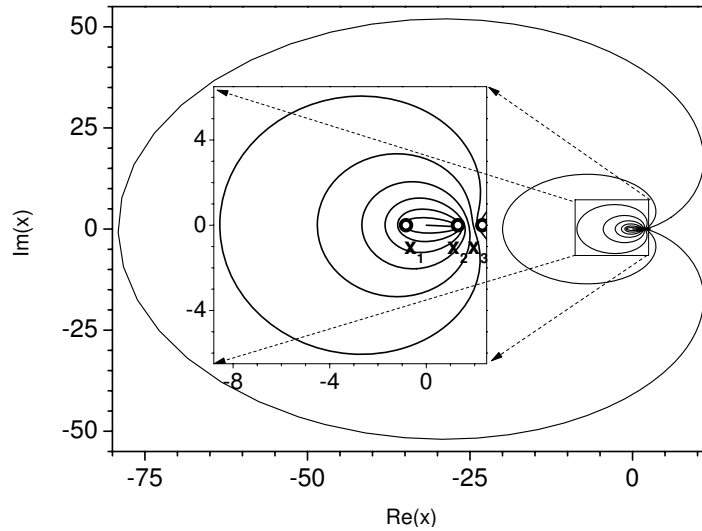
## 3. Classical description of tunneling phenomenon

Recently, in [9] it has been argued that "quantum" effects can be explained in terms of classical trajectories. In particular, the tunneling effect for a potential

$$V(x) = x^2/2 - gx^3 \quad (3)$$

has been discussed. In this case, the lowest state is a quasi-stationary state whose lifetime  $\tau$ , defined by the population of the bound state  $P(t) = e^{-t/\tau}$ , can be approximated for small  $g$  using WKB theory by the expression [10]

$$\tau = \frac{1}{2}g\sqrt{\pi} \exp(2/15g^2) \quad (4)$$



**Рис. 1.** The trajectory in the complex  $x$ -plane of a classical particle with complex energy (4) at  $g = 2/\sqrt{125}$ . Open circles in the insertion show the turning points  $x_1$ ,  $x_2$  and  $x_3$ .

In Fig.8 of the paper [9] (which coincides with insertion in Fig.1 of present paper<sup>‡</sup>), a complex classical trajectory with lifetime (4) at  $g = 2/\sqrt{125}$  is represented with the comment

"... initially, as the particle crosses the real axis to the right of the middle turning point, its trajectory is concave leftward, but as time passes, the trajectory becomes concave rightward. It is clear that by the fifth orbit the right turning point has gained control, and we can declare that the classical particle has now 'tunneled' out and escaped from the parabolic confining potential. The time at which this classical changeover occurs is approximately at  $t = 40$ . This is in good agreement with the lifetime of the quantum state in (8), whose numerical value is about 20."

However, if the time increases further, one can see from Fig.1 that the trajectory does not escape toward the right side but continues to rotate mostly on the opposite side. On the other hand, we can compare the quantum lifetime  $\tau$  (4), and the classical time to reach the right turning point  $t_c$  -

$$\operatorname{Re} x(t_c) = \operatorname{Re} x_3 \quad (5)$$

- proposed in [9] as a classical analogue of  $\tau$ . It is seen from Table 1 that there is nothing in common between these two quantities in spite of the "good agreement" declared in [9]. Thus, the effect discussed is an artificial result which has no relation to quantum theory.

<sup>‡</sup> Fig.1 and Tab.1 have been prepared by Alexander Gusev

**Таблица 1.** The classical time  $t_c$  (5) and the quantum lifetime  $\tau$  (4) versus coupling constant  $g$ .

$g$	0.12522	0.14311	0.16099	0.17888
$t_c$	15009	1385	220	49
$\tau$	547	85	24	10

#### 4. Chaos and irregular motion

The next example is the study of irregular motion in classical mechanics. The main point in this approach is the interpretation of bifurcation as a source of chaos. Interest in the chaotic behaviour is explained by an attempt to understand the origin of the arrow of time provided by the Second Law of Thermodynamics, which says that in an isolated system, entropy tends to increase in time. But there is a fundamental contradiction between such evolution and classical mechanics - the first is 100% irreversible in time whereas classical mechanics is 100% reversible. Classical mechanics rather deals with pseudo-chaotic evolution. This evolution is due to the fundamental difference between rational and irrational numbers in mathematics, which has no relation to nature. Generally speaking, the axioms of mathematics always provide behaviour that is reversible in time. We can obtain irreversible evolution only if we introduce a stochastic concept like 'probability' which is beyond standard mathematics.

#### 5. Concluding remarks

Here three examples have been presented. The same metaphysical aspect occurs in some other approaches such as special relativity. At the basis of relativistic mechanics lies a Minkowski space  $\{x, y, z, ct\}$ . However this representation has well-known unresolvable paradoxes. In the two-body problem we should use two sets of variables:  $\{x_1, y_1, z_1, ct_1\}$  for the first particle and  $\{x_2, y_2, z_2, ct_2\}$  for the second one (see, e.g., [11] p.188 where these variables are introduced without comments). What is the meaning of  $t_1$  and  $t_2$ ? It is a scholastic question like "How many devils can be located on a pin head?". It has no connection with experiment or reality. Thus, the self-consistent relativistic mechanics for few-body systems cannot be formulated. In this context, the standard relativistic approach to the description of a *single* particle looks more like a Kunststück, than a theory. In the Maxwell theory there is no such paradox, since the electromagnetic field is the sole object. The next contradiction in special relativity is the twin paradox. On the one hand special relativity is kinematics since it connects coordinates and time in two inertial frames of reference and mutual deceleration of time measured in two different frames has no physical meaning. Then, the time delay in the twin paradox can be connected with the stage when one of the frames of reference is accelerated. This

stage does not depend on how long both frames of reference move uniformly. But the prediction of a time delay from special relativity is proportional to this interval of time. In the book [11] on page 278 Fritz Rohrlich comments on this situation:

"This result has been repeatedly stated in the form of an apparent contradiction known as the *twin paradox* or *clock paradox*. (Since the author has great difficulty constructing paradoxes from clear mathematical facts, he will not attempt to do so.)"

At the basis of both paradoxes lies the postulate that the speed of light is the same for all inertial observers. In fact this statement is beyond common sense; probably, it is out of our mentality since we have no direct experience and adequate vocabulary in this field. Here it is pertinent to quote the last paragraph from [2] :

"A scientific approach is quite restricted because at its roots ordinary language lies which is not certain and complete in principle. For instance, it admit such paradoxes as "Can God create a stone so heavy that he cannot lift it?". Another example that demonstrates the incompleteness of vocabulary is the fact that physics cannot be represented in Eskimo language, which has dozens of words for different types of snow (snow that fell down yesterday, snow on which a dog-sled passed, *etc.*); however, there is no word 'snow', which is too abstract for them. But what is the level of our mentality (language  $\Rightarrow$  mentality)? However, it is the sole tool for communication. In mathematics, the trace of this incompleteness is Gödel's theorem [12], which states that there are true propositions about the natural world that cannot be proved from the axioms."

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